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2,222,169

SHORT WAVE TUNING

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2 Sheets-Sheet 1

Fig. 1a.

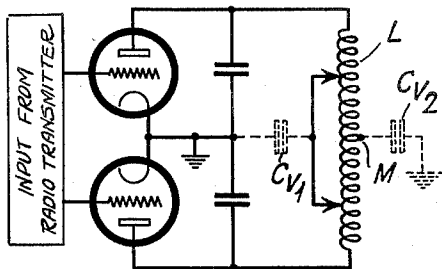


Fig. 1b.

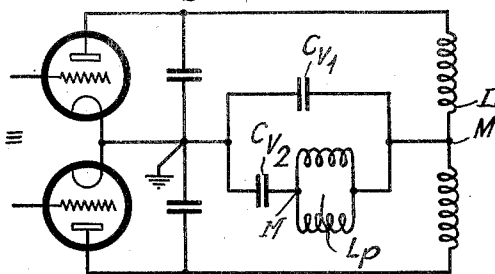


Fig. 2

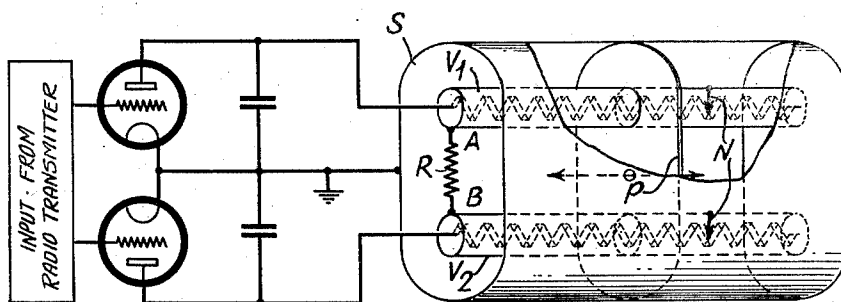
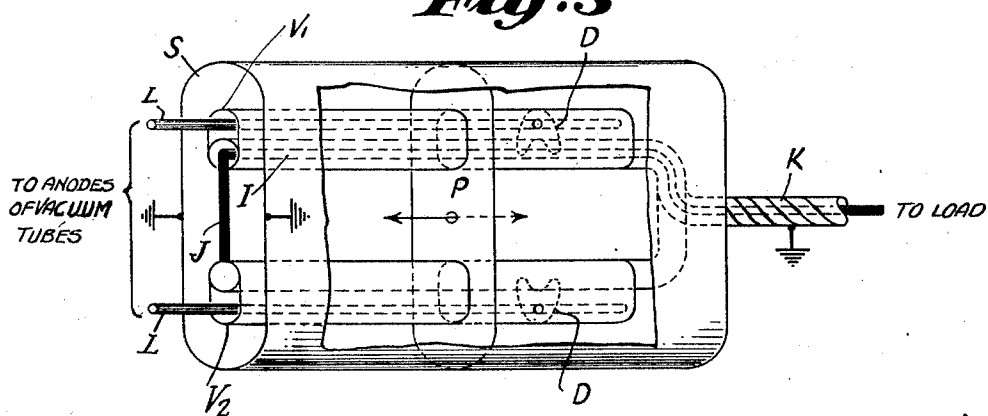


Fig. 3



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Fig. 4

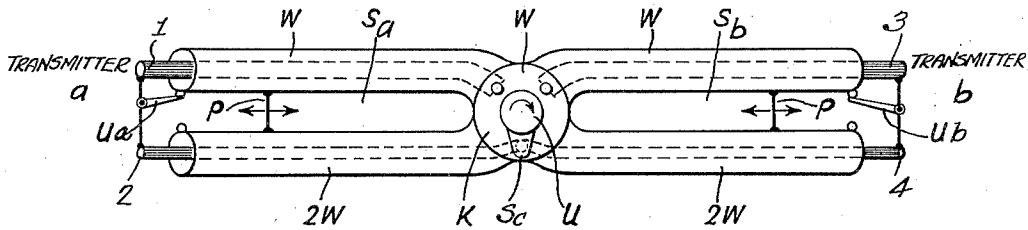


Fig. 5

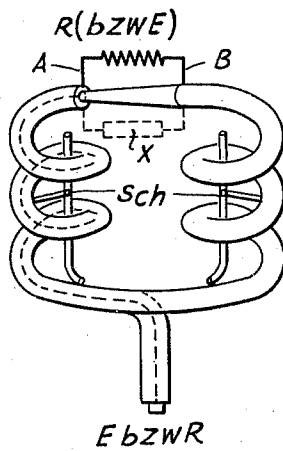
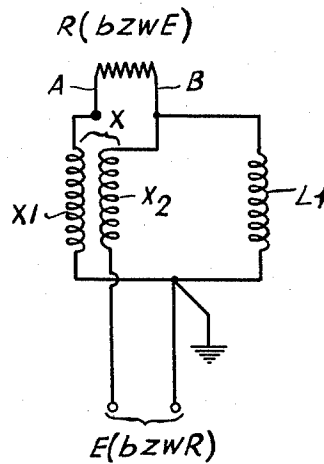


Fig. 6



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SHORT WAVE TUNING

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4 Claims. (Cl. 178-44)

This invention relates to an improved tuned circuit arrangement for short wave transmitters.

An object of this invention is to provide a transmitter of very high power with an improved tuning arrangement covering a wide wave length range.

A feature of this invention is an arrangement for causing an equalizing or compensating current to flow over the outer skin of the shield of variable inductance which at the same time causes proper antenna coupling, thereby maintaining the major part of the variometers at earth potential so that troublesome resonance of the short-circuited parts is avoided.

In the operation of short-wave transmitters and more particularly of ultra-short-wave transmitters of large power, the tuning of which, inside a comparatively wide wave-band, must be continuously or steadily variable, difficulties are often occasioned by the ends of coils or variometer parts which are disconnected when working with the shorter waves. These difficulties are described by reference to Fig. 1a which shows a push-pull circuit organization which is probably most extensively used in practice.

When working with short waves, the central portion of coil L (or of the slide variometer) is short-circuited. The distributed capacity of the short-circuiter to ground shall be designated by CV₁. The distributed capacitance of the short-circuited median part of the coil, in first approximation, may be assumed to be in the neighborhood of the center of this part. The same is designated by CV₂ as shown in Fig. 1a, and in Fig. 1b, which is simply replotted from Fig. 1a. As may be seen from Fig. 1b, there thus results between cathode and midpoint of coil "M" a parallel circuit, one branch of which consists of a pure capacity CV₁ and whose other branch, however, comprises a series arrangement of capacity and inductance, i. e., the parallel connection L_p of the two halves of the short-circuited part of L. Quite apart from resonance with harmonics of the working wave which occasionally may cause very troublesome effects, particularly that part is dangerous for which L_p comes to be in series resonance with CV₂ for the operating wave. For it will be noted that in this case the center of the coil M is connected with the cathode through a short-circuit, with the result that the plate circuit which was so far uniform and unbroken is divided into two halves. The consequence is that neutralization fails to operate. One way to remedy this situation is to ground damping resistances from the midpoint

of the coil M. In the substitute or equivalent scheme, Fig. 1b, these damping resistances would be parallel to CV₂; therefore, in the following, an arrangement shall be described in which the distributed capacities of the shielding are rendered harmless. This tuning arrangement for the radio frequency transmitter wherein the tuning is done by short-circuiting of windings on the side of the tuning coil opposite the radio frequency source, and wherein the consumer or output is connected in series to the end of the coil opposite the radio frequency source, is characterized by that the coil is surrounded by a screen connected on one side to said coil at the coil end opposite the radio frequency source, said screen being grounded externally at such a place that the largest portion of the screen is at ground potential and so that the consumer is connected at a point of the screen portion which does not yet possess ground potential. This idea will be described more in detail as follows:

At the tuning coils which are tuned by short-circuiting of the windings, some means, as pointed out above, are necessary for avoiding a disturbing wave occurring in the circuits due to stray capacitances. Furthermore, at the said tuning coils, the coupling of the consumer is very difficult, because an inductive coupling is out of question, due to the shortcircuiting of windings, and due to lack of uniformity of coupling caused thereby. The capacitive coupling to the oscillating circuit is also not desirable at short waves as additional capacitances have to be generally avoided at the arrangement. Therefore, only a taking off of the useful energy at the circuit containing the coil is feasible whereby the consumer is connected in series with the coil.

In the drawings, Fig. 1a shows a known type of push-pull circuit and Fig. 1b shows the equivalent electrical circuit for Fig. 1a;

Fig. 2 shows the invention applied to a push-pull stage and adapted to a balanced load; and

Fig. 3 shows a modification of Fig. 2 adapted to an unbalanced load;

Fig. 4 shows how Fig. 3 may be modified to couple an unbalanced load to a push-pull transmitter;

Fig. 5 shows another circuit for coupling a push-pull to an unbalanced load; and

Fig. 6 is the electrically equivalent circuit for Fig. 5.

Referring to Fig. 2, for a more detailed description of the invention, let us for the moment forget cylindrical outer shield S. The coils (or straight inner conductors in the case of short

waves) inside V_1 and V_2 , together with the anode to ground capacitor, form a push-pull tank for the vacuum tubes. The tuning of this tank is adjusted by the sliders shown as arrows N. Current flowing from the plate or anode of the vacuum tube passes along coil (or straight conductor) inside V_1 , then through the arrow to the inner surface of V_1 and along this surface to the point where plate P is located, then along plate P to the plane of symmetry of the system which acts as a fictitious ground since an equal and opposite current flows to this plane from the plate or anode of the other vacuum tube. In the region between P and the arrow N, the current returning on the inner surface of V_1 is just equal and opposite to that traveling along the conductor inside of V_1 , so that there is no drop of potential along the outer surface of V_1 in this region. But the plate tank circuit just described is magnetically coupled to the load circuit consisting of the outer surface of V_1 between A and P, the plate P, the outer surface of V_2 between P and B, and the load R connected between B and A. The mutual inductance between the tank circuit and the load circuit may be varied by moving P, thus adjusting the loading on the tubes to a desired amount.

Finally, an outer shield S connected to P, may surround the entire assembly.

Fig. 3 shows how a plate tank circuit of the sort shown in Fig. 2 may be variably coupled to an unsymmetrical load without appreciably upsetting the balance of the tank circuit. Here, each side of the tank consists again in the circuit commencing at the left end of conductor L, going along to the bridging member D, which serves to tune the tank, thence along the inside of the conductor surrounding L back to P and along P to the plane of symmetry. As explained in connection with Fig. 2, there is no fall of potential along the outer surfaces of V_1 or V_2 to the right of P, but the tank current circulating in the circuit just described is magnetically coupled to a load circuit starting at the substantially ground potential point where P meets V_2 , continuing to the left along the outside of V_2 , thence by strap J to the conductor I inside that compartment of V_2 which does not contain L and along conductor I through the cable K to the load. This load circuit is essentially similar to the load circuit of Fig. 2, except that in Fig. 3 the voltages induced in the load circuit are connected in series starting from ground so as to apply to the ungrounded end of the load the total voltage induced.

Fig. 4 shows how Fig. 3 may be extended to adapt an unbalanced load to either or both of two push-pull transmitters. Here, P is again the coupling adjustment, the pipes L being part of the tank inductances. Let us suppose only transmitter "a" is to operate. The loop arm Sc of the load cable inner conductor is turned to the upper left contact thereby connecting the load to the circuit through I, by switch u_a to 3, then to the outer sheath of K. This circuit is magnetically coupled to the tank described. If transmitter "b" alone is used, a corresponding description applies. If both transmitters are used, switches " u_a , u_b " and "U" are turned as shown, and then each transmitter has a coupled load circuit P, L, u_a (or u_b) 2 (or 4), inner conductor of K, load, outer conductor of cable K and back over L to P, coupled to its tank. The inner conductors are made to form the impedances shown so as to preclude any more standing waves than necessary.

Fig. 5 shows another push-pull—to—unbalanced load. The push-pull plate tank includes the adjustable coils and starting from the high potential point of the right coil, the inner conductor of the left coil picks up by virtue of unity coupling an equal voltage additive thereto, making a total voltage for the load equal to the sum of the coil voltages.

Fig. 6 is electrically like 5. If the left and right coils were connected, for example, to the push-pull plates of A and B, then the load voltage equals the drop across the right coil plus the (equal) voltage induced in X_2 from X_1 .

Another conceivable plan would be to shield the short-circuited part of the winding against ground. To be sure, this last-named step would raise the capacity of CV_1 in the majority of instances in an inadmissible measure so that this circuit scheme would be useful only in isolated instances.

In what follows, an arrangement shall be disclosed in which the distributed capacities of the shielding are rendered harmless by causing a current to flow over the shielding designed to set up such a field that even after a comparatively short length the shield is at ground potential, while the other dimensions of the variometer become immaterial. This idea is illustrated in Fig. 2. The variometer is split into two halves, V_1 and V_2 , which are confined inside a shield or "can." If the waves are not unduly long, then, in lieu of the wound variometers, there could be used simply a concentric straight double line short-circuited at the end, the length of the said line being made adjustable by the aid of a shiftable bottom indicated at D in Fig. 3. As a result of the shielding, no field exists outside these variometers. Between the two points A and B is connected the useful resistance or load R which in this instance must present symmetry in reference to earth, for instance, by a Lecher-wire line, connection of a phase transformer, or an LC-LC bridge. In order that the proper current resulting in the desired power may be caused to flow through this effective or ohm resistance, it is necessary to provide a variable shunt in parallel thereto, variation being produced preferably by the shiftable plate P. In other words, an equalizing current flows through the outside of one of the variometer shields in bottom P and back by way of the outside of the second variometer shield. The ground plate P is at earth potential inasmuch as it is united with the grounded shield S. Hence, the variometers may extend into the space adjoining on the right hand side as far as may be desired. These ends under no circumstances are liable any longer to assume a state of resonance for any waves at all, whether fundamental or harmonic, so that with one stroke all of the difficulties hereinbefore outlined have been eliminated.

If the plate direct current potential is to be kept away from the useful resistance or load R, it may be found suitable to choose a variometer shield of the cylinder-condenser type, in other words, in the form of a ceramic cylinder being metallized inside and outside and made of a kind of material possessing a high dielectric constant.

The arrangement as hereinbefore described makes it also possible, in a simple manner, to dispense with the expensive phase (shifting) transformer in a case such as mostly met with in practice where the load is dissymmetric (simple cable). An exemplified embodiment is shown in Fig. 3, where for the sake of simplicity

the variometers are shown in the form of short-circuited concentric lines with shiftable bottom D. It will be seen that if the cable K grounded on the outside is shifted along one of the variometers, that is, the upper variometer, and if a very similar cable sheath without core which at the input end is united with the core of the other cable is placed parallel to the other (lower) variometer shield in a very similar way, for symmetry's sake, then the equalizing current flowing along the cable sheath will cause the voltage on the outer sheath of the cable and thus also the core (which, as will be obvious, is linked to the same field) to drop at the shiftable bottom plate P to ground potential, with the result that the fact that the cable is buried in the ground will no longer result in any dissymmetry.

The same method also makes it possible, in a simple manner, in the case of paralleling of two cascades generally met with in short-wave transmitters for the purpose of increasing the power, to choose correctly the characteristic impedance to be fit for the particular mode of operation that has been chosen (cascade *a* alone, cascade *b* alone, cascades *a* and *b* in parallel). For the sake of simplicity, there are shown in Fig. 4 solely the symmetricizing loops S_a and S_b of the two stages, *a* and *b* working individually or in parallel. If the two symmetricizing loops S_a and S_b are joined at their closed ends (whence also the antenna energy feeder cable is brought), and if in each of the upper halves a core resulting in the characteristic impedance W of the energy feeder cable is threaded or shifted, whereas in the other (lower) halves is introduced an inner conductor to connect the stages *a* and *b* directly so that the characteristic impedance $2W$ results, then, by the agency of a simple change-over switch U, the cable, without change of its characteristic impedance, may be united either with transmitter *a* or transmitter *b*, or, in case of parallel operation, with the junction point of the two lines of characteristic impedance $2W$ so that a matched state will be obtained also in this instance. The inner conductor which is not used is simply short-circuited at the sending end with the outer sheath by the use of switch *z*.

The methods hereinbefore disclosed at the same time afford a chance to avoid the radio frequency cooling-water losses. The variometer inner conductors which are directly connected with the water-cooled tube anodes, by virtue of the equalizing current flowing on the outer sheath of the shield, are at ground potential at their ends facing the anode, so that, if the cooling water is admitted at this place, the variometers not only are insured the requisite cooling, but at the same time all high-frequency losses due to water columns being at radio frequency potential are avoided.

The idea underlying the symmetricizing loop is not confined to its loop form. In fact, it would be possible also to choose an embodiment of the kind shown in Fig. 5. The cables are here constructed variometer-fashion, while a slide contact or bridge piece is provided for the purpose of adjusting the proper impedance required for the current flowing through the skin. It would also be feasible to leave the coils constant and thus insure the requisite shunt by the aid of an inductive or capacitive reactance X connected in parallel relation to the load resistance R. Because of the greater length required for longer waves, certain practical difficulties may

be encountered in an attempt to use wound cable. In such an instance, it may be of greater advantage to carry into practice the electrical equivalent scheme of the circuit organization of Fig. 6. For instance, a coil with reactance X_2 coupled with the left-hand coil having reactance X_1 is to be the equivalent of the line with its core. In order that this substitute or equivalent scheme may be chosen correctly from a quantitative viewpoint, the coupling between the aforesaid coils X_1 and X_2 must be chosen such that the mutual reactance therebetween is equal to the reactances X_1 of inductance L_1 . Then the current flowing from point A through X_1 to ground will induce in the coil of reactance X_2 by virtue of said coupling a voltage which is equal to the voltage impressed at point A, with the consequence that the presuppositions respecting line symmetry will be actually fulfilled. To illustrate the action of the circuit of Figs. 5 and 6 by means of a specific example, let us suppose that at a given instant, the potential at point A is +1000 volts and that at point B is -1000 volts. The potential of the live or ungrounded conductor at the bottom of Fig. 6 is the potential of point B. Since this induced voltage is arranged to be equal to the voltage drop in the coil between A and ground, namely 1000 volts, the resulting potential of the aforesaid live conductor is -2000 volts, thus, the original balanced voltage of 2000 volts impressed between A and B is delivered as an unbalanced voltage of 2000 volts between the live conductor and the ground conductor at the lower portion of the figures. Of course, as to the rest, in all of the exemplified embodiments hereinbefore discussed, E, M, F, E and load resistance R are always interchangeable.

What is claimed is:

1. In a radio frequency circuit arrangement comprising a push-pull vacuum tube stage having anode, grid and cathode circuits, the grid circuit of each tube connected to a source of radio frequency energy, an inductance element connected to the anode circuit of each tube, means for tuning said inductance element, said means comprising a variable member connecting each inductance element in series, an electrically conductive shielding member surrounding each inductance element and connected to said means, said shielding members being enveloped by a second electrically conductive shield, a movable short-circuiting clip disposed between said first and second mentioned shields by means of which said second shield is effectively connected to ground.

2. In a radio frequency circuit arrangement comprising a push-pull vacuum tube stage having anode, grid and cathode circuits, the grid circuit of each tube connected to a source of radio frequency energy, an electrically conductive shielded inductance element connected to the anode circuit of each tube, means for tuning said inductance element, said means comprising a variable member effectively connecting each inductance to its surrounding shield, an electrically conductive shielding member surrounding both of said shielded inductance elements and connected therewith, said electrically conductive shielding member being grounded on the outside at a point at which the major portion of the shield will be at ground potential, the output circuit of said push-pull stage being coupled to said electrically conductive shielding member at a point which is not at ground potential.

3. A short wave amplifier circuit including an

electron discharge device having an anode and a cathode, a long inductive member connected at one end to said anode, an electrically conductive shield surrounding said inductive member, a
5 first adjustable connection of low impedance between a point on said inductive member and an adjacent point on said shield, said first connection being adjustable over a portion at least of
10 the length of said member and shield for varying the inductance between said anode and said first connection, and a second adjustable connection located externally of said shield and connecting said shield to a point of relatively fixed
15 alternating current potential, and a load coupled to said amplifier over a circuit extending from the anode end of said shield through said second adjustable connection to said cathode.

4. A short wave amplifier circuit including a pair of push-pull connected electron discharge

devices each having an anode and a cathode, a long inductive member connected at one end to each of said anodes, an electrically conductive shield surrounding each of said inductive members, an adjustable short-circuiting member between a point on each inductive member and its
5 surrounding shield for varying the inductance between the associated anode and said short-circuiting member, and an adjustable connection located externally of said shields between said
10 anodes and said short-circuiting members for connecting said shields to a point of relatively fixed alternating current potential, and a load having one end grounded and having mutual inductances with the two shield portions between
15 the anodes and said adjustable connection.

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